Verifying Antenna Ground Connections

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How to Verify Your Ground Connections are Good

For a number of years I have been active on 160 meters. As I improved my station, I came to learn that a good ground system is imperative to success on that band. I use a vertical and "feed it against ground." This means a good ground system is 50% of my "antenna system": the better my ground the better my antenna.

Most often, the weakest link in a grounding system is the bonding from one conductor to the next. This would be from the ground wire/cable to the bonding clamp, and the connection from the clamp to the ground rod (sometimes called an electrode). In RF environments, multiple antenna systems, ground rods, and ground radials may be involved so naturally they all must make proper connection. These bonding points can degrade with time due to vibration, climatic changes, weather, moisture causing galvanic corrosion, and other reasons. Your ground connections should be checked periodically.

There are several ways of checking the integrity of bonding conductors in a grounding system.

First, visually inspect the entire site, looking for loose connections, broken connection points and corroded connections: repair any of these.

Secondly, do a mechanical inspection, physically stressing each connection looking for less obvious loose or broken tie points.

Lastly, do an electrical bond-resistance test. Here, the most appropriate instrument to employ is a micro-ohmmeter. The micro-ohmmeter is far more effective in checking the quality of a resistive bond than a multimeter or other resistance-measuring device. The micro-ohmmeter conducts the test with a higher current. In this way, the quality of the bond is electrically stressed, eliminating the appearance of good resistance from weak connection points, such as a connection point where a single strand of wire is the bonding point. In this case, the multimeter, using low current, would potentially show this single-strand bond as a good connection. The micro-ohmmeter will quickly identify it as a poor bond by actually causing the single strand connection to open.

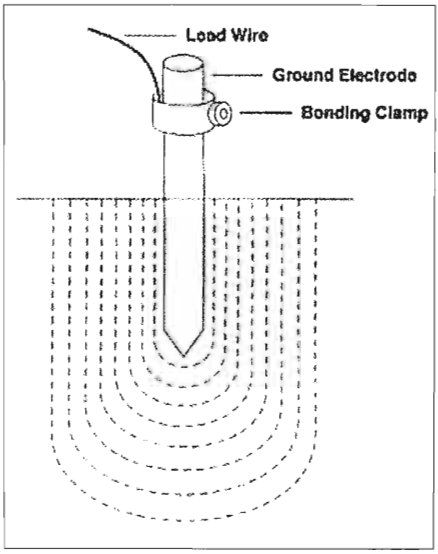

Figure 1: Grounding Electrode and Major Bonding Locations

Before reviewing the actual testing process, let's first examine the components of a grounding electrode. Notice how **Figure 1** shows a typical grounding electrode with three major bonding points: the ground electrode, the bonding clamp, and the lead wire. All three

points should be checked with respect to each other.

The 10-amp micro-ohmmeter is an effective tool for testing any grounding bonding system. It employs a low voltage, typically 8-10 volts DC, and a high current, typically adjustable from 1 to 10 amps. A commercial micro-ohmmeter, such as the model from AEMC Instrument (http://www.aemc.com), consists of a test instrument and a set of heavy test leads (I am not affiliated with AEMC in any way.). Once the leads are attached to the connection, a button is pushed and the connection resistance is read directly. (See below for an inexpensive way the ham operator can test his bonding connection.)

A good resistive connection will be in the micro-ohm region and at worse case, in the milli-ohm region. This test procedure should occur for every bond along the grounding system from the tower and all equipment right down to each and every grounding rod and radial. This testing of the bonding system should be conducted quarterly, or at very least annually, to ensure a good quality grounding system.

How to Make Your Own Micro-Ohmmeter

The micro-ohm meter is not a test instrument that a typical ham will have, of course. But, you can easily approximate the function by following the steps described below, which I have done.

Locate a fairly inexpensive automobile battery charger in the 6-to-10 amp charging range. I used both a very old K-Mart charger, rated at 6 amperes, and also a newer "Starline" by Starline Products, Minneapolis, Minnesota. It also was rated at 6 amps, but the meter reads to 8 amps. I used an automotive charger since it has high enough high internal resistance and will endure momentary shorts repeatedly. You could use a bench DC power supply that has current limiting. Set it for 10-to-20 amps current limit and measure all day long! The automotive charger can be found at garage sales and flea markets for just a few dollars and makes a great piece of test gear.

Locate or borrow a high current ammeter and—with caution—determine the maximum current the charger will deliver in a short-circuit condition. I found that the Starline automobile battery changer would deliver 35 amps when I shorted the clip leads together. Of course this is for a slit second, since a prolonged short will open the internal circuit breaker.

Next, place one charger lead on your ground rod, and then momentarily touch the other lead to the bonding clamp first, and then to the lead wire. Of course, small sparks will fly as the 35 amps flow through the connection. This exercise will prove that the connection is electrically sound: if it can pass 35 amps DC, it can pass your RF with little attenuation. Should the need arise, the connection can safely pass lightning surges to ground.

To estimate the resistance of the connection, place a DC voltmeter across the connection under test. For example, place one of the voltmeter leads on the ground lead wire, and the other connection on the ground rod. Verify the meter connections are secure and then momentarily place the battery charger leads at the same location. Watch the voltmeter move up slightly as you pass about 35 amps thru the connection. If the connection is poor less current will flow, resulting in a poorer "short" to the battery charger. This will allow the measured voltage to rise, indicating higher resistance and more voltage drop at this connection.

I suggest that you set the voltmeter to a high-voltage range at first. This will avoid possible meter damage should the connection be open and the full 12, or more, volts be applied directly to the meter. Once you verify the connection is

Example	Measured volts	Calculated resistance
a	0.1	0.00285 ohm
b	0.17	0.0048 ohm
c	0.28	0.008 ohm
d	0.13	0.0037 ohm

Table 1: Measured Bonding Resistance

good, you can set your voltmeter to the lowest scale.

When doing my tower and ground system, I found very good repeatability in my readings and measurable variances in the different connections. I found all my connections, which have been in place for over 4 years, would handily pass 35 amps. In fact, I found I could quickly verify all connections simply by tapping one lead to each ground connection of my radial fan-out. By listening to the battery charger meter ping across the scale with the high current flow, I was assured that this connection was intact. Using this system, a 40-radial ground system can be checked in a matter of minutes.

For experimentation purposes, I measured the voltage across selected connections to see what resulted. Assume 35 ampere current flow (admittedly this value will be inaccurate, but I have no way to determine high currents at various loads). Given the measured voltage and assumed current, I used ohm's law to estimate the bond's resistance. **Table 1** shows sample readings.

This simple process will verify the connections are good. You can also identify good connections and better ones. I found several that looked robust and well made, yet they measured poorly. This summer, after my other projects are done, I will come back to that connection and see if I can improve it.

Figure 2 shows how I made the above measurements. I tested the resistance from the tower section to one of the radials. This tested the connections between the tower, a stainless steel anti-galvanizing sheet, the ground wire distribution block, and the wire itself. I show a digital VOM, but an analog meter might give better readings due to the short duration the charger will endure the short.

Figure 2: Making Bonding Measurements

Thanks to the help of many in the Chiburban Mobileers (especially Howie, W9NHM, SK), who operate exclusively on 160 meters, I became an advocate of a good ground radial system.

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